

OU4 TRADE STUDY

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DISPOSAL CONTAINER SIZE OPTIMIZATION STUDY FOR CHEMICAL STABILIZATION – CEMENT

40730-ES-0002

Rev 0
September 1999

ORIGINAL



FERNALD

Environmental Management Project

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Disposal Container Optimization Study Chemical Stabilization – Cement

INTRODUCTION

The purpose of this study is to determine the optimum size for a disposal container, evaluate the cost difference between concrete and steel containers, and determine the impact that different waste loading values have on the final cost for the Chemical Stabilization – Cement technology. Optimizing the container size will ensure that the maximum amount of stabilized material is being shipped with each container (a gross weight of 21,000 pounds per container), thus minimizing the total number of containers to be disposed and reducing the total life-cycle cost. The information provided in this paper will be used to support the Silos 1 and 2 Revised Feasibility Study by providing a basis for the disposal container configuration and material of construction. This study does not include the structural design of a waste container.

RELATED STUDIES

A study was performed which included the design of a box that met the structural and shielding requirements that are applicable to a DOT Specification 7A Type A container (Reference SEG Design Completion Report – Enduropak SIFCON Concrete Packaging for OU4 Vitrified Materials). The SEG container was designed to provide adequate shielding for a container for vitrified waste. Therefore, the evaluation of vitrification containers is not considered in this paper. In addition to the SEG container design report, an Engineering Study has been performed to determine the most economically and technically feasible vitrified waste form (Reference Report 40730-ES-001 – Vitrification Waste Form Study). This paper does not include the evaluation of a container for the Chemical Stabilization–Other (Chem-Other) technology. The container proposed by the Proof of Principle (POP) vendor for Chem-Other stabilization alternative is proprietary and is fabricated with internal components specific to the Chem-Other technology and must therefore be constructed out of steel. However, the Chem-Other POP demonstration produced a grout that had acceptable physical properties, so the waste loading value reported for the Chem - Other demonstration is evaluated as one of the waste loading options in this paper.

The SEG Enduropak disposal container is a reinforced concrete container that meets the shielding and structural requirements for vitrified Silos 1 and 2 material. These properties set the SEG container as the baseline option for this engineering study. However, since the box was designed for vitrification, the container wall thickness provides more shielding than is required for cement stabilized waste.

RESULTS

The costs associated with purchasing and preparing empty containers as well as shipping and disposal costs for filled containers were evaluated for the various waste loading values

for both concrete and steel containers. Table 1 presents the results for the alternatives evaluated and the parameters associated with each container. The total life-cycle costs ranged from \$42 million to \$86 million. The lower cost alternatives were associated with the higher waste loading values and concrete containers. However, given the restriction on waste loading (reference Revised Feasibility Study Report for Silos 1 and 2, 40730-RP-0001, Appendix G), the option with the lowest life-cycle cost is the concrete disposal container with a 4" thick wall and a 30% waste loading formula. The total life cycle cost of this option is approximately \$52 million. The total number of containers to ship is 5,699 (not including additional containers associated with the re-work of out of spec grout or the recycle of water treatment solids). The exterior length, width, and height dimensions of the container are 74", 67", and 70" respectively. The external height dimension includes a 4" addition to account for forklift runners. The external volume is 201 ft³, the volume of waste per container is 118 ft³ (based on a 90% container fill ratio). The empty container weight is 9,299 lbs, and the weight of a filled container is approximately 21,000 lbs.

BASES/ASSUMPTIONS

General

Containers associated with the rework of off - spec grout were not included – In the Design Basis for the Silos 1 and 2 Revised Feasibility Study, it was specified that one percent of the total number of containers produced will fail to meet acceptance criteria and will need to be re-stabilized. Since the percentage of re-work containers is assumed to be the same for all the alternatives, the cost associated with re-work will not materially affect the results of this study.

Container Specifications – In general, the container dimensions were set in a similar configuration to the SEG disposal container. The external height dimension includes a 4" addition to account for forklift runners.

90% fill fraction – It is required that the solidification/stabilization formula has a relatively high slump to ensure that the grout will be able to fill a container without the assistance of mechanical compaction. This requirement allows the container to be filled to any level desired. In order to reduce the risk of overfilling the container and to leave space for an absorbent pad, a limit of 90% full has been established. This packing fraction is applied to the calculation of the gross container weight. However, for shielding calculations, a worst case assumption of a 100% filled container is made.

Transportation

21,000 lb per container weight limit – The maximum gross weight of each truck shipment (full container(s) of treated Silo 1 and 2 material) shall not exceed 42,000 lbs. (21,000 per container, for a two container shipment). The 42,000 lb limit is based on Site Procedure PT-0006, Packaging Low-Level Radioactive waste in ISO containers. The limit was

established to meet a DOT limit of 80,000 lbs for over-the-road shipments when truck, trailer, fuel, tie-down equipment, etc., are factored into gross weight.

Container and Shielding

Concrete shielded box cost of \$5,000 – A concrete shielded container meeting the DOT Specification 7A type A container requirements has been developed for the transport and disposal of glass gems (Reference SEG Design Completion Report – Enduropak SIFCON Concrete Packaging for OU4 Vitrified Materials). The container weighs approximately 12,000 lbs and the estimated cost is \$5,000 (Reference letter from B. Roy, Vice President of Engineering for SEG, to Bob Vogel, dated January 31, 1995; Subject: Containers for vitrified K-65 materials). It is assumed that a concrete box with slightly modified dimensions can be fabricated for approximately the same price. Minor changes in size will change the volume of concrete used to fabricate the walls by less than a cubic yard. This will not impact the fabrication labor time of the container.

Steel shielded box costs – A vendor was contacted and requested to provide cost estimates for steel containers with L x W x H dimensions of 72" x 60" x 60" for containers with varying wall thickness. The cost estimates included the cost associated with materials, fabrication (including full penetration welds), bolted lid with a gasket, and runners for forklift tines. The actual cost for construction may vary, but the price estimates may be used for a quantitative comparison. The phone conversation notes, including price quotes, are provided as Attachment 1.

Shielding must reduce the surface dose to 70 mr/hr – 49 CFR 173.441 b(3) requires that the dose rate at a distance of 2 meters from the truck be less than 10 millirem per hour (mr/hr). It has been determined through Microshield calculations that in order to meet this requirement; it is necessary to have a dose rate on contact with the container less than 70 mr/hr (Reference Microshield calculations, Attachment 2)

Container shielding calculations were made using Microshield software using the following assumptions: the source geometry is a rectangular solid, the source term constituent make-up is concrete, the source term density is 99 lb/ft³, the concrete shielding is National Bureau of Standards (NBS) concrete.

Waste Loading and Density

15% waste loading – 15% waste loading was determined to be on the low end of the waste loading range for cement stabilization. It was chosen to evaluate whether or not a low waste loading and hence, less required shielding, produced a lower life cycle cost.

25% waste loading – Chem-Nuclear Systems demonstrated with their POP-formula for the 72 hour demonstration that the 25% waste loading formula met the necessary strength and TCLP requirements as well as performed well from a material handling aspect.

30 percent waste loading – 30% waste loading is an intermediate waste loading value and has met structural and TCLP requirements on actual K-65 material (FEMP OU4 Treatability Report) and can be formulated so material handling capabilities are acceptable.

40 percent waste loading – The Chemical Stabilization – Cement POP formula for the 72 hour demonstration showed that a 40% waste loading formula can meet the necessary strength and TCLP requirements. However, there were material handling issues with this grout formula.

99 lb/ft³ grout density – Different grout formulas, and hence, different waste loadings have varying grout densities. The POP vendors reported grout densities ranging from 90 lb/ft³ to 108 lb/ft³, corresponding to waste loading values ranging from 40% to 22%. Since a final grout formula to treat the Silos 1 and 2 material has not been developed, an intermediate density of 99 lb/ft³ has been established as the baseline for this study.

FINAL COST EVALUATION

A summary of the comparison calculations is presented in Table 1. The Total Package/Prep/Shipping cost is determined by multiplying the total number of containers by a factor that includes the following: the cost per container (varying), a cost for labor and preparation associated with the container of \$545, and a cost per shipment of \$4,200 per shipment. In addition, the external volume of all containers to dispose is multiplied by \$7.50/ft³ to account for burial costs at NTS. This cost is added to the package/prep/shipping cost to determine the **life cycle cost**. The **life cycle cost** for each alternative is listed at the bottom of Table 1. A calculation was performed to verify that the formulas used in Table 1 are accurate (calculation 40730-CA-0008).

COMPARISON

For all cases evaluated, a higher waste loading produced a lower **life cycle cost** by reducing the number of containers to dispose. Also for all cases, a lower cost was associated with the alternatives that employed the concrete shielded container opposed to the metal shielded container. Since shielding is primarily a function of the mass of shielding material, the weight of the steel container is approximately equal to the weight of the concrete containers for a constant waste loading value. Thus, the weight of material that can be placed in a metal container versus a concrete container must also be about equal so the 21,000 lb gross container weight limit is not exceeded. Therefore, the higher life cycle costs associated with the metal containers can be attributed to the higher purchase cost of the metal container.

The lowest total cost alternative is a 40% waste loading using a 4½" concrete shielded container. The **life cycle cost** of this alternative was \$42 million. However, it has been determined that in order to produce a grout that minimizes process and handling risks, it is necessary to increase the slump, consequently lowering its waste loading. The Revised Feasibility Study Report for Silos 1 and 2, 40730-RP-0001, Appendix G, indicates that a

reasonable formulation produces a 30% waste loading grout. Therefore, the lowest total cost for a feasible option is the 30% waste loading with the concrete shielded container. The life cycle cost of this option is \$52 million. The total number of containers to dispose is 5699. The L x W x H dimensions of the container are 74" x 67" x 70" respectively. The external height dimension includes a 4" addition to account for forklift runners.

Table 1: Container Size Evaluation

	Waste Loading / Container Type								
Waste Loading	15 wt%	15 wt%	25 wt%	25 wt%	30 wt%	30 wt%	40 wt%	40 wt%	40 wt%
Container Material	Concrete	Steel	Concrete	Steel	Concrete	Steel	Concrete	Steel	SEG (Baseline)
Box Length "L" (in)	78.00	76.00	78.00	72.00	74.00	66.00	72.00	72.00	72.00
Box Width "W" (in)	68.00	63.50	66.00	61.00	67.00	61.00	67.00	57.00	60.00
Box height "H" (in)	67.00	63.00	66.00	60.00	66.00	61.00	66.00	57.00	51.60
Concrete Wall Thickness (in)	2.00	NA	3.00	NA	4.00	NA	4.50	NA	6.00
Steel Wall Thickness (in)	NA	0.500	NA	0.875	NA	1.125	NA	1.250	NA
Interior Volume (ft ³)	173	176	150	153	131	142	121	135	61
Shipping Volume (ft ³) = 90% fill fraction	155	158	135	137	118	128	108	122	55
Exterior Volume (ft ³) incl. 4" rise for fork lift	218	195	209	176	201	168	195	163	131
density of steel wall (lb/ft ³)	NA	490	NA	490	NA	490	NA	490	NA
density of concrete wall (lb/ft ³)	147	NA	147	NA	147	NA	147	NA	170
density of waste material (lb/ft ³)	99	99	99	99	99	99	99	99	99
	wt steel shell X 1.25		wt steel shell X 1.10		wt steel shell X 1.00		wt steel shell X 1.00		
Weight of steel wall*	NA	5278	NA	7319	NA	8165	NA	8836	NA
Weight of concrete shielding**	5524	NA	7529	NA	9299	NA	10042	NA	12000
Weight of material in box	15385	15677	13365	13588	11645	12663	10739	12062	5457
Total weight of box and material	20909	20955	20894	20907	20944	20828	20781	20898	17457
Containers to ship	8628	8467	5959	5861	5699	5241	4635	4127	9120
Purchase cost per container (\$)	5000	6000	5000	7100	5000	8000	5000	8400	5000
Labor & prep cost/pkg (\$)	545	545	545	545	545	545	545	545	545
cost/shipment	4200	4200	4200	4200	4200	4200	4200	4200	4200
Total pkg, prep, shipping cost (Mil \$)	66.0	73.2	45.6	57.1	43.6	55.8	35.4	45.6	69.7
Disposal cost (mil \$)	14.1	12.4	9.3	7.7	8.6	6.6	6.8	5.0	9.0
TOTAL DISPOSAL COST (mil \$)	80	86	55	65	52	62	42	51	79
Rank (1 = Least Expensive Alternative)	8	9	4	6	3	5	1	2	7

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Attachment 1

Metal Container Price Quote - Telephone Conversation Notes

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The cost estimate for a rectangular steel box for the Box Optimization Study was obtained by contacting B.J. Metals in Cleveland, Ohio. B.J. Metals is a container manufacturer with the ability to fabricate containers with custom dimensions.

Contact at B.J. Metals: Randy Frye
Phone Number: 888-871-5051
Date of Call: 04/01/1999
Contact made by: Brian Kauffman

Request:

Provide a rough cost estimate for a rectangular metal box with L x W x H dimensions of 72" x 60" x 60" respectively for the following wall thicknesses:

Wall Thickness	Cost (\$)	Reduced Cost (\$)*
1/2"	6800	6000
3/4"	7600	6800
1"	8400	7500
1 1/4"	9300	8400

The cost estimate also includes a price associated with fabricating the box with fork lift runners, full penetration welds, a lid that can be bolted securely in place and a lid gasket.

*The Reduced Cost applies a 10% (approximate) discount *assumed* to be associated with a large order due to the number of containers that will be required (between 4000 to 6000 containers).

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Attachment 2

Microshield Calculations

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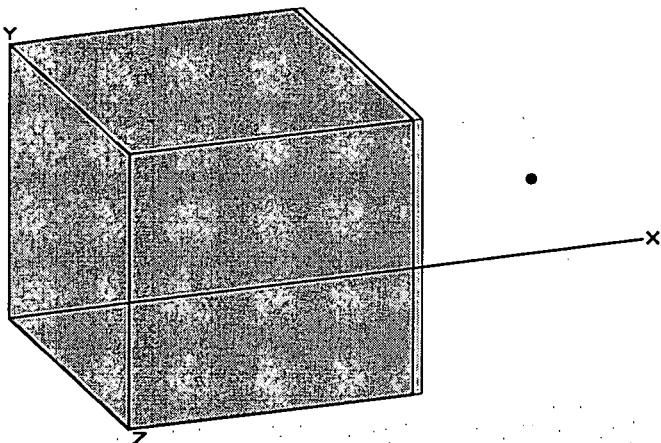
15 wt% Waste Loading Concrete Container

Page : 1
DOS File: 15BOX2.MS5
Run Date: Not Run
Run Time: NA
Duration: NA

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File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: 15% waste loading
Description: Concrete Box - 2" wall
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	165.1 cm	5 ft 5.0 in
Width	193.04 cm	6 ft 4.0 in
Height	162.56 cm	5 ft 4.0 in

Dose Points

	X	Y	Z
# 1	171.18 cm 5 ft 7.4 in	81.28 cm 2 ft 8.0 in	96.52 cm 3 ft 2.0 in
# 2	200.18 cm 6 ft 6.8 in	81.28 cm 2 ft 8.0 in	96.52 cm 3 ft 2.0 in
# 3	270.18 cm 8 ft 10.4 in	81.28 cm 2 ft 8.0 in	96.52 cm 3 ft 2.0 in
# 4	370.18 cm 12 ft 1.7 in	81.28 cm 2 ft 8.0 in	96.52 cm 3 ft 2.0 in

Shields

Shield Name	Dimension	Material Density
Source	5.18e+06 cm ³	Concrete 1.587
Shield 1	5.08 cm	Concrete 2.35
Air Gap	Air	0.00122

Source Input

Grouping Method : Standard Indices

Number of Groups : 25

Lower Energy Cutoff : 0.015

Photons < 0.015 : Excluded

Library : Grove

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^3$	Bq/cm ³
Ac-227	8.6500e-003	3.2005e+008	1.6696e-003	6.1775e+001
Ac-228	1.2500e-003	4.6250e+007	2.4127e-004	8.9270e+000
Bi-210	2.2776e-001	8.4271e+009	4.3961e-002	1.6266e+003
Bi-211	8.6500e-003	3.2005e+008	1.6696e-003	6.1775e+001
Bi-212	2.5700e-003	9.5090e+007	4.9605e-004	1.8354e+001
Bi-214	5.3784e-001	1.9900e+010	1.0381e-001	3.8410e+003
Pa-231				
Pa-234				
Pa-234m	7.8000e-004	2.8860e+007	1.5055e-004	5.5704e+000
Pb-210	2.2776e-001	8.4271e+009	4.3961e-002	1.6266e+003
Pb-211	8.6500e-003	3.2005e+008	1.6696e-003	6.1775e+001
Pb-212	2.5700e-003	9.5090e+007	4.9605e-004	1.8354e+001
Pb-214	5.3784e-001	1.9900e+010	1.0381e-001	3.8410e+003
Po-210	3.1684e-001	1.1723e+010	6.1155e-002	2.2627e+003
Po-212	2.5700e-003	9.5090e+007	4.9605e-004	1.8354e+001
Po-214	5.3784e-001	1.9900e+010	1.0381e-001	3.8410e+003
Po-215	8.6500e-003	3.2005e+008	1.6696e-003	6.1775e+001
Po-216	2.5700e-003	9.5090e+007	4.9605e-004	1.8354e+001
Po-218	5.3784e-001	1.9900e+010	1.0381e-001	3.8410e+003

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Page : 2
DOS File: 15BOX2.MS5
Run Date: Not Run
Run Time: NA
Duration: NA

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<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm^3</u>
Ra-223	8.6400e-003	3.1968e+008	1.6677e-003	6.1703e+001
Ra-224	2.5700e-003	9.5090e+007	4.9605e-004	1.8354e+001
Ra-226	5.3784e-001	1.9900e+010	1.0381e-001	3.8410e+003
Ra-228	1.2500e-003	4.6250e+007	2.4127e-004	8.9270e+000
Rn-219	8.6500e-003	3.2005e+008	1.6696e-003	6.1775e+001
Rn-220	2.5700e-003	9.5090e+007	4.9605e-004	1.8354e+001
Rn-222	5.3784e-001	1.9900e+010	1.0381e-001	3.8410e+003
Th-227	8.6500e-003	3.2005e+008	1.6696e-003	6.1775e+001
Th-228	2.5700e-003	9.5090e+007	4.9605e-004	1.8354e+001
Th-230	7.7690e-002	2.8745e+009	1.4995e-002	5.5483e+002
Th-231	6.0000e-005	2.2200e+006	1.1581e-005	4.2849e-001
Th-232	1.2500e-003	4.6250e+007	2.4127e-004	8.9270e+000
Th-234	7.8000e-004	2.8860e+007	1.5055e-004	5.5704e+000
Tl-207	8.6500e-003	3.2005e+008	1.6696e-003	6.1775e+001
Tl-208	2.5700e-003	9.5090e+007	4.9605e-004	1.8354e+001
U-234	1.5050e-003	5.5685e+007	2.9049e-004	1.0748e+001
U-235	1.1000e-004	4.0700e+006	2.1232e-005	7.8557e-001
U-238	7.8000e-004	2.8860e+007	1.5055e-004	5.5704e+000

Buildup

The material reference is : Source

Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

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15 wt% Waste Loading Steel Container

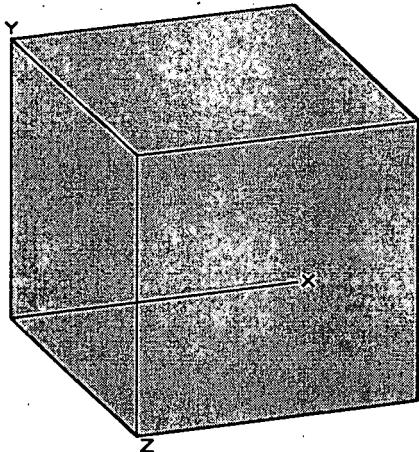
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 Fluor Daniel Fernald

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 Run Time: 3:28:25 PM
 Duration: 00:01:60

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File Ref: _____
 Date: _____
 By: _____
 Checked: _____

Case Title: 15 wt%
 Description: 1/2" Steel box
 Geometry: 13 - Rectangular Volume



Source Dimensions

Length	154.94 cm	5 ft 1.0 in
Width	190.5 cm	6 ft 3.0 in
Height	154.94 cm	5 ft 1.0 in

Dose Points

	X	Y	Z
# 1	157.21 cm	77.47 cm	92.25 cm
	5 ft 1.9 in	2 ft 6.5 in	3 ft 0.3 in

Shields

<u>Shield Name</u>	<u>Dimension</u>	<u>Material</u>	<u>Density</u>
Source	4.57e+06 cm ³	Concrete	1.587
Shield 1	1.27 cm	Iron	7.86
Air Gap		Air	0.00122

Source Input

Grouping Method : Standard Indices

Number of Groups : 25

Lower Energy Cutoff : 0.015

Photons < 0.015 : Excluded

Library : Grove

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm³</u>
Ac-227	8.3100e-003	3.0747e+008	1.8171e-003	6.7233e+001
Ac-228	1.2000e-003	4.4400e+007	2.6240e-004	9.7087e+000
Bi-210	2.1874e-001	8.0934e+009	4.7831e-002	1.7697e+003
Bi-211	8.3100e-003	3.0747e+008	1.8171e-003	6.7233e+001
Bi-212	2.4700e-003	9.1390e+007	5.4010e-004	1.9984e+001
Bi-214	5.1652e-001	1.9111e+010	1.1294e-001	4.1789e+003
Pa-231				
Pa-234				
Pa-234m	7.5000e-004	2.7750e+007	1.6400e-004	6.0679e+000
Pb-210	2.1874e-001	8.0934e+009	4.7831e-002	1.7697e+003
Pb-211	8.3100e-003	3.0747e+008	1.8171e-003	6.7233e+001
Pb-212	2.4700e-003	9.1390e+007	5.4010e-004	1.9984e+001
Pb-214	5.1652e-001	1.9111e+010	1.1294e-001	4.1789e+003
Po-210	3.0428e-001	1.1258e+010	6.6535e-002	2.4618e+003
Po-212	2.4700e-003	9.1390e+007	5.4010e-004	1.9984e+001
Po-214	5.1652e-001	1.9111e+010	1.1294e-001	4.1789e+003
Po-215	8.3100e-003	3.0747e+008	1.8171e-003	6.7233e+001
Po-216	2.4700e-003	9.1390e+007	5.4010e-004	1.9984e+001
Po-218	5.1652e-001	1.9111e+010	1.1294e-001	4.1789e+003
Ra-223	8.3100e-003	3.0747e+008	1.8171e-003	6.7233e+001
Ra-224	2.4700e-003	9.1390e+007	5.4010e-004	1.9984e+001
Ra-226	5.1652e-001	1.9111e+010	1.1294e-001	4.1789e+003
Ra-228	1.2000e-003	4.4400e+007	2.6240e-004	9.7087e+000
Rn-219	8.3100e-003	3.0747e+008	1.8171e-003	6.7233e+001
Rn-220	2.4700e-003	9.1390e+007	5.4010e-004	1.9984e+001

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 Run Time: 3:28:25 PM
 Duration: 00:01:60

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<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm^3</u>
Rn-222	5.1652e-001	1.9111e+010	1.1294e-001	4.1789e+003
Th-227	8.3100e-003	3.0747e+008	1.8171e-003	6.7233e+001
Th-228	2.4700e-003	9.1390e+007	5.4010e-004	1.9984e+001
Th-230	7.4610e-002	2.7606e+009	1.6315e-002	6.0364e+002
Th-231	6.0000e-005	2.2200e+006	1.3120e-005	4.8543e-001
Th-232	1.2000e-003	4.4400e+007	2.6240e-004	9.7087e+000
Th-234	7.5000e-004	2.7750e+007	1.6400e-004	6.0679e+000
Tl-207	8.3100e-003	3.0747e+008	1.8171e-003	6.7233e+001
Tl-208	2.4700e-003	9.1390e+007	5.4010e-004	1.9984e+001
U-234	1.0100e-003	3.7370e+007	2.2085e-004	8.1715e+000
U-235	1.0000e-004	3.7000e+006	2.1866e-005	8.0906e-001
U-238	7.5000e-004	2.7750e+007	1.6400e-004	6.0679e+000

Buildup

The material reference is : Source

Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

Results

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u>	<u>Fluence Rate</u>	<u>Exposure Rate</u>	<u>Exposure Rate</u>
		<u>MeV/cm²/sec</u>	<u>MeV/cm²/sec</u>	<u>mR/hr</u>	<u>mR/hr</u>
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	1.156e+05	4.808e-277	2.062e-28	4.124e-278	1.769e-29
0.02	6.149e+05	2.456e-125	1.727e-27	8.506e-127	5.982e-29
0.03	6.327e+05	1.091e-41	3.929e-27	1.081e-43	3.894e-29
0.04	1.642e+06	1.063e-19	4.259e-19	4.699e-22	1.884e-21
0.05	5.655e+08	3.026e-09	2.029e-08	8.062e-12	5.406e-11
0.06	1.244e+07	2.463e-07	2.267e-06	4.893e-10	4.503e-09
0.08	4.604e+09	8.403e-02	9.242e-01	1.330e-04	1.463e-03
0.1	8.154e+07	2.241e-02	2.493e-01	3.428e-05	3.814e-04
0.15	3.446e+07	1.205e-01	1.145e+00	1.985e-04	1.885e-03
0.2	2.157e+09	2.041e+01	1.671e+02	3.603e-02	2.949e-01
0.3	4.124e+09	1.071e+02	7.025e+02	2.032e-01	1.333e+00
0.4	7.393e+09	3.549e+02	1.979e+03	6.916e-01	3.855e+00
0.5	3.655e+08	2.766e+01	1.357e+02	5.429e-02	2.663e-01
0.6	9.292e+09	1.013e+03	4.471e+03	1.977e+00	8.727e+00
0.8	1.850e+09	3.572e+02	1.345e+03	6.795e-01	2.559e+00
1.0	6.011e+09	1.805e+03	6.050e+03	3.328e+00	1.115e+01
1.5	3.646e+09	2.426e+03	6.701e+03	4.082e+00	1.127e+01
2.0	5.115e+09	5.859e+03	1.445e+04	9.060e+00	2.234e+01
3.0	9.121e+07	2.156e+02	4.619e+02	2.925e-01	6.267e-01
TOTALS:	4.535e+10	1.219e+04	3.646e+04	2.040e+01	6.244e+01

- 2552

25 wt% Waste Loading Concrete Container

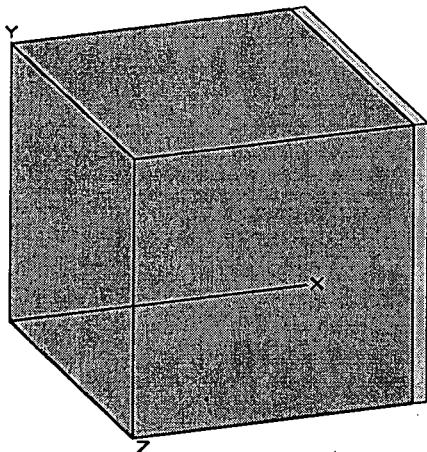
MicroShield v5.01 (5.01-00093)
Fluor Daniel Fernald

Page : 1
DOS File: 25BOX3.MS5
Run Date: March 31, 1999
Run Time: 3:18:36 PM
Duration: 00:01:59

File Ref: _____
Date: _____
By: _____
Checked: _____

2552

Case Title: 25 wt%
Description: 3" concrete box
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	149.86 cm	4 ft 11.0 in
Width	182.88 cm	6 ft
Height	149.86 cm	4 ft 11.0 in

Dose Points

	X	Y	Z
# 1	158.48 cm	74.93 cm	91.44 cm
	5 ft 2.4 in	2 ft 5.5 in	3 ft

Shields

Shield Name	Dimension	Material	Density
Source	4.11e+06 cm ³	Concrete	1.587
Shield 1	7.62 cm	Concrete	2.35
Air Gap		Air	0.00122

Source Input

Grouping Method : Standard Indices

Number of Groups : 25

Lower Energy Cutoff : 0.015

Photons < 0.015 : Excluded

Library : Grove

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^3$	Bq/cm^3
Ac-227	1.3092e-002	4.8440e+008	3.1876e-003	1.1794e+002
Ac-228	1.8955e-003	7.0132e+007	4.6151e-004	1.7076e+001
Bi-210	3.4466e-001	1.2752e+010	8.3917e-002	3.1049e+003
Bi-211	1.3092e-002	4.8440e+008	3.1876e-003	1.1794e+002
Bi-212	3.8901e-003	1.4393e+008	9.4717e-004	3.5045e+001
Bi-214	8.1386e-001	3.0113e+010	1.9816e-001	7.3319e+003
Pa-231				
Pa-234				
Pa-234m	1.1792e-003	4.3629e+007	2.8710e-004	1.0623e+001
Pb-210	3.4466e-001	1.2752e+010	8.3917e-002	3.1049e+003
Pb-211	1.3092e-002	4.8440e+008	3.1876e-003	1.1794e+002
Pb-212	3.8901e-003	1.4393e+008	9.4717e-004	3.5045e+001
Pb-214	8.1386e-001	3.0113e+010	1.9816e-001	7.3319e+003
Po-210	4.7944e-001	1.7739e+010	1.1673e-001	4.3192e+003
Po-212	3.8901e-003	1.4393e+008	9.4717e-004	3.5045e+001
Po-214	8.1386e-001	3.0113e+010	1.9816e-001	7.3319e+003
Po-215	1.3092e-002	4.8440e+008	3.1876e-003	1.1794e+002
Po-216	3.8901e-003	1.4393e+008	9.4717e-004	3.5045e+001
Po-218	8.1386e-001	3.0113e+010	1.9816e-001	7.3319e+003
Ra-223	1.3092e-002	4.8440e+008	3.1876e-003	1.1794e+002
Ra-224	3.8901e-003	1.4393e+008	9.4717e-004	3.5045e+001
Ra-226	8.1386e-001	3.0113e+010	1.9816e-001	7.3319e+003
Ra-228	1.8955e-003	7.0132e+007	4.6151e-004	1.7076e+001
Rn-219	1.3092e-002	4.8440e+008	3.1876e-003	1.1794e+002
Rn-220	3.8901e-003	1.4393e+008	9.4717e-004	3.5045e+001

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<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm^3</u>
Rn-222	8.1386e-001	3.0113e+010	1.9816e-001	7.3319e+003
Th-227	1.3092e-002	4.8440e+008	3.1876e-003	1.1794e+002
Th-228	3.8901e-003	1.4393e+008	9.4717e-004	3.5045e+001
Th-230	1.1755e-001	4.3494e+009	2.8622e-002	1.0590e+003
Th-231	8.8161e-005	3.2620e+006	2.1466e-005	7.9422e-001
Th-232	1.8955e-003	7.0132e+007	4.6151e-004	1.7076e+001
Th-234	1.1792e-003	4.3629e+007	2.8710e-004	1.0623e+001
Tl-207	1.3092e-002	4.8440e+008	3.1876e-003	1.1794e+002
Tl-208	3.8901e-003	1.4393e+008	9.4717e-004	3.5045e+001
U-234	1.5869e-003	5.8716e+007	3.8638e-004	1.4296e+001
U-235	1.6530e-004	6.1162e+006	4.0248e-005	1.4892e+000
U-238	1.1792e-003	4.3629e+007	2.8710e-004	1.0623e+001

Buildup

The material reference is : Source

Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

Results

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u>	<u>Fluence Rate</u>	<u>Exposure Rate</u>	<u>Exposure Rate</u>
		<u>MeV/cm²/sec</u>	<u>No Buildup</u>	<u>With Buildup</u>	<u>mR/hr</u>
0.015	1.816e+05	2.435e-79	2.914e-28	2.089e-80	2.499e-29
0.02	9.688e+05	2.154e-36	2.446e-27	7.463e-38	8.473e-29
0.03	9.623e+05	2.656e-14	5.009e-14	2.632e-16	4.965e-16
0.04	2.586e+06	3.078e-08	8.737e-08	1.361e-10	3.864e-10
0.05	8.911e+08	1.483e-03	6.225e-03	3.950e-06	1.658e-05
0.06	1.959e+07	3.486e-04	2.018e-03	6.924e-07	4.008e-06
0.08	7.254e+09	1.159e+00	9.951e+00	1.834e-03	1.575e-02
0.1	1.285e+08	5.792e-02	6.163e-01	8.862e-05	9.429e-04
0.15	5.434e+07	8.832e-02	1.072e+00	1.454e-04	1.765e-03
0.2	3.398e+09	1.153e+01	1.337e+02	2.036e-02	2.360e-01
0.3	6.498e+09	5.813e+01	5.586e+02	1.103e-01	1.060e+00
0.4	1.165e+10	2.043e+02	1.644e+03	3.981e-01	3.203e+00
0.5	5.759e+08	1.698e+01	1.173e+02	3.332e-02	2.302e-01
0.6	1.464e+10	6.581e+02	4.000e+03	1.285e+00	7.808e+00
0.8	2.916e+09	2.545e+02	1.270e+03	4.841e-01	2.415e+00
1.0	9.471e+09	1.380e+03	5.941e+03	2.545e+00	1.095e+01
1.5	5.745e+09	2.102e+03	7.068e+03	3.537e+00	1.189e+01
2.0	8.059e+09	5.537e+03	1.605e+04	8.562e+00	2.483e+01
3.0	1.436e+08	2.285e+02	5.502e+02	3.101e-01	7.465e-01
TOTALS:	7.145e+10	1.045e+04	3.735e+04	1.729e+01	6.339e+01

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2552

25 wt% Waste Loading Steel Container

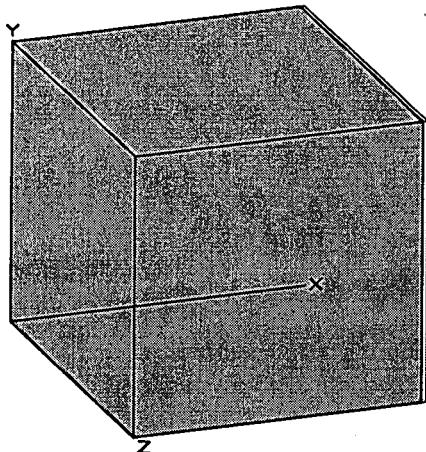
MicroShield v5.01 (5.01-00093)
Fluor Daniel Fernald

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DOS File: 25BOX78.MS5
Run Date: March 31, 1999
Run Time: 3:13:35 PM
Duration: 00:02:00

File Ref: _____
Date: _____
By: _____
Checked: _____

-- 2552

Case Title: 25 wt%
Description: 7/8" Steel box
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	150.495 cm	4 ft 11.3 in
Width	178.435 cm	5 ft 10.3 in
Height	147.955 cm	4 ft 10.3 in

Dose Points

X	Y	Z
# 1 153.7175 cm	73.9775 cm	89.2175 cm
5 ft 0.5 in	2 ft 5.1 in	2 ft 11.1 in

Shields

<u>Shield Name</u>	<u>Dimension</u>	<u>Material</u>	<u>Density</u>
Source	3.97e+06 cm ³	Concrete	1.587
Shield 1	2.223 cm	Iron	7.86
Air Gap		Air	0.00122

Source Input

Grouping Method : Standard Indices

Number of Groups : 25

Lower Energy Cutoff : 0.015

Photons < 0.015 : Excluded

Library : Grove

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm^3</u>
Ac-227	1.2665e-002	4.6860e+008	3.1876e-003	1.1794e+002
Ac-228	1.8336e-003	6.7844e+007	4.6151e-004	1.7076e+001
Bi-210	3.3341e-001	1.2336e+010	8.3917e-002	3.1049e+003
Bi-211	1.2665e-002	4.6860e+008	3.1876e-003	1.1794e+002
Bi-212	3.7632e-003	1.3924e+008	9.4717e-004	3.5045e+001
Bi-214	7.8731e-001	2.9130e+010	1.9816e-001	7.3319e+003
Pa-231				
Pa-234				
Pa-234m	1.1407e-003	4.2205e+007	2.8710e-004	1.0623e+001
Pb-210	3.3341e-001	1.2336e+010	8.3917e-002	3.1049e+003
Pb-211	1.2665e-002	4.6860e+008	3.1876e-003	1.1794e+002
Pb-212	3.7632e-003	1.3924e+008	9.4717e-004	3.5045e+001
Pb-214	7.8731e-001	2.9130e+010	1.9816e-001	7.3319e+003
Po-210	4.6380e-001	1.7161e+010	1.1673e-001	4.3192e+003
Po-212	3.7632e-003	1.3924e+008	9.4717e-004	3.5045e+001
Po-214	7.8731e-001	2.9130e+010	1.9816e-001	7.3319e+003
Po-215	1.2665e-002	4.6860e+008	3.1876e-003	1.1794e+002
Po-216	3.7632e-003	1.3924e+008	9.4717e-004	3.5045e+001
Po-218	7.8731e-001	2.9130e+010	1.9816e-001	7.3319e+003
Ra-223	1.2665e-002	4.6860e+008	3.1876e-003	1.1794e+002
Ra-224	3.7632e-003	1.3924e+008	9.4717e-004	3.5045e+001
Ra-226	7.8731e-001	2.9130e+010	1.9816e-001	7.3319e+003
Ra-228	1.8336e-003	6.7844e+007	4.6151e-004	1.7076e+001
Rn-219	1.2665e-002	4.6860e+008	3.1876e-003	1.1794e+002
Rn-220	3.7632e-003	1.3924e+008	9.4717e-004	3.5045e+001

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-- 2552

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm^3</u>
Rn-222	7.8731e-001	2.9130e+010	1.9816e-001	7.3319e+003
Th-227	1.2665e-002	4.6860e+008	3.1876e-003	1.1794e+002
Th-228	3.7632e-003	1.3924e+008	9.4717e-004	3.5045e+001
Th-230	1.1372e-001	4.2075e+009	2.8622e-002	1.0590e+003
Th-231	8.5285e-005	3.1555e+006	2.1466e-005	7.9422e-001
Th-232	1.8336e-003	6.7844e+007	4.6151e-004	1.7076e+001
Th-234	1.1407e-003	4.2205e+007	2.8710e-004	1.0623e+001
Tl-207	1.2665e-002	4.6860e+008	3.1876e-003	1.1794e+002
Tl-208	3.7632e-003	1.3924e+008	9.4717e-004	3.5045e+001
U-234	1.5351e-003	5.6800e+007	3.8638e-004	1.4296e+001
U-235	1.5991e-004	5.9166e+006	4.0248e-005	1.4892e+000
U-238	1.1407e-003	4.2205e+007	2.8710e-004	1.0623e+001

Buildup

The material reference is : Source

Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

Results

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u>	<u>Fluence Rate</u>	<u>Exposure Rate</u>	<u>Exposure Rate</u>
		<u>MeV/cm²/sec</u>	<u>No Buildup</u>	<u>With Buildup</u>	<u>mR/hr</u>
0.015	1.757e+05	0.0000e+00	3.320e-28	0.0000e+00	2.848e-29
0.02	9.372e+05	1.064e-207	2.787e-27	3.687e-209	9.654e-29
0.03	9.309e+05	1.491e-67	6.122e-27	1.477e-69	6.067e-29
0.04	2.501e+06	5.240e-31	4.362e-26	2.317e-33	1.929e-28
0.05	8.620e+08	3.009e-15	2.668e-14	8.016e-18	7.107e-17
0.06	1.895e+07	5.632e-11	7.594e-10	1.119e-13	1.508e-12
0.08	7.017e+09	1.509e-03	2.656e-02	2.388e-06	4.203e-05
0.1	1.243e+08	1.958e-03	3.549e-02	2.996e-06	5.430e-05
0.15	5.257e+07	3.703e-02	5.532e-01	6.099e-05	9.110e-04
0.2	3.287e+09	9.057e+00	1.125e+02	1.599e-02	1.986e-01
0.3	6.286e+09	6.230e+01	5.876e+02	1.182e-01	1.115e+00
0.4	1.127e+10	2.338e+02	1.809e+03	4.555e-01	3.525e+00
0.5	5.571e+08	1.975e+01	1.305e+02	3.876e-02	2.562e-01
0.6	1.416e+10	7.674e+02	4.461e+03	1.498e+00	8.707e+00
0.8	2.821e+09	2.952e+02	1.412e+03	5.616e-01	2.686e+00
1.0	9.162e+09	1.589e+03	6.578e+03	2.929e+00	1.213e+01
1.5	5.557e+09	2.365e+03	7.720e+03	3.979e+00	1.299e+01
2.0	7.796e+09	6.056e+03	1.721e+04	9.364e+00	2.662e+01
3.0	1.390e+08	2.371e+02	5.688e+02	3.217e-01	7.717e-01
TOTALS:	6.912e+10	1.163e+04	4.059e+04	1.928e+01	6.899e+01

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30 wt% Waste Loading Concrete Container

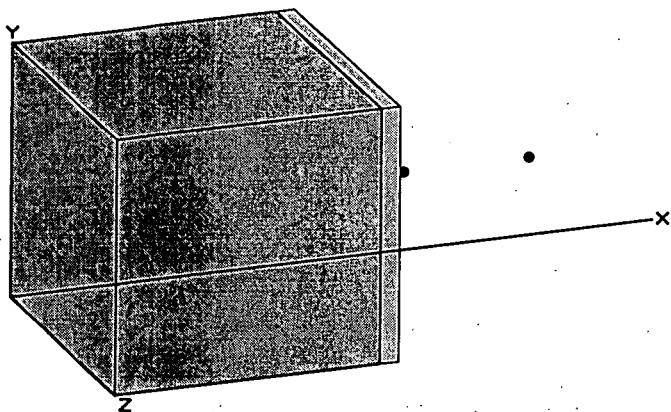
MicroShield v5.01 (5.01-00093)
Fluor Daniel Fernald

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DOS File: 30BOX4.MS5
Run Date: June 4, 1999
Run Time: 10:53:36 AM
Duration: 00:07:46

File Ref: _____
Date: _____
By: _____
Checked: _____

-- 2552

Case Title: 30% waste loading
Description: Concrete Box - 4" wall
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	147.32 cm	4 ft 10.0 in
Width	162.56 cm	5 ft 4.0 in
Height	144.78 cm	4 ft 9.0 in

Dose Points

	X	Y	Z
# 1	158.48 cm 5 ft 2.4 in	77.47 cm 2 ft 6.5 in	86.36 cm 2 ft 10.0 in
# 2	187.48 cm 6 ft 1.8 in	77.47 cm 2 ft 6.5 in	86.36 cm 2 ft 10.0 in
# 3	257.48 cm 8 ft 5.4 in	77.47 cm 2 ft 6.5 in	86.36 cm 2 ft 10.0 in
# 4	357.48 cm 11 ft 8.7 in	77.47 cm 2 ft 6.5 in	86.36 cm 2 ft 10.0 in

Shields

<u>Shield Name</u>	<u>Dimension</u>	<u>Material Density</u>
Source	3.47e+06 cm ³	Concrete 1.587
Shield 1	10.16 cm	Concrete 2.35
Air Gap		Air 0.00122

Source Input

Grouping Method : Standard Indices

Number of Groups : 25

Lower Energy Cutoff : 0.015

Photons < 0.015 : Excluded

Library : Grove

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm³</u>
Ac-227	1.2700e-002	4.6990e+008	3.6629e-003	1.3553e+002
Ac-228	1.8000e-003	6.6600e+007	5.1914e-004	1.9208e+001
Bi-210	3.3350e-001	1.2340e+010	9.6186e-002	3.5589e+003
Bi-211	1.2700e-002	4.6990e+008	3.6629e-003	1.3553e+002
Bi-212	3.8000e-003	1.4060e+008	1.0960e-003	4.0551e+001
Bi-214	7.8750e-001	2.9138e+010	2.2713e-001	8.4037e+003
Pa-231				
Pa-234				
Pa-234m	1.1000e-003	4.0700e+007	3.1726e-004	1.1738e+001
Pb-210	3.3350e-001	1.2340e+010	9.6186e-002	3.5589e+003
Pb-211	1.2700e-002	4.6990e+008	3.6629e-003	1.3553e+002
Pb-212	3.8000e-003	1.4060e+008	1.0960e-003	4.0551e+001
Pb-214	7.8750e-001	2.9138e+010	2.2713e-001	8.4037e+003
Po-210	4.6390e-001	1.7164e+010	1.3380e-001	4.9504e+003
Po-212	3.8000e-003	1.4060e+008	1.0960e-003	4.0551e+001
Po-214	7.8750e-001	2.9138e+010	2.2713e-001	8.4037e+003
Po-215	1.2700e-002	4.6990e+008	3.6629e-003	1.3553e+002
Po-216	3.8000e-003	1.4060e+008	1.0960e-003	4.0551e+001
Po-218	7.8750e-001	2.9138e+010	2.2713e-001	8.4037e+003

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 Duration: 00:07:46

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<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm^3</u>
Ra-223	1.2700e-002	4.6990e+008	3.6629e-003	1.3553e+002
Ra-224	3.8000e-003	1.4060e+008	1.0960e-003	4.0551e+001
Ra-226	7.8750e-001	2.9138e+010	2.2713e-001	8.4037e+003
Ra-228	1.8000e-003	6.6600e+007	5.1914e-004	1.9208e+001
Rn-219	1.2700e-002	4.6990e+008	3.6629e-003	1.3553e+002
Rn-220	3.8000e-003	1.4060e+008	1.0960e-003	4.0551e+001
Rn-222	7.8750e-001	2.9138e+010	2.2713e-001	8.4037e+003
Th-227	1.2700e-002	4.6990e+008	3.6629e-003	1.3553e+002
Th-228	3.8000e-003	1.4060e+008	1.0960e-003	4.0551e+001
Th-230	1.1380e-001	4.2106e+009	3.2821e-002	1.2144e+003
Th-231	1.0000e-004	3.7000e+006	2.8841e-005	1.0671e+000
Th-232	1.8000e-003	6.6600e+007	5.1914e-004	1.9208e+001
Th-234	1.1000e-003	4.0700e+007	3.1726e-004	1.1738e+001
Tl-207	1.2700e-002	4.6990e+008	3.6629e-003	1.3553e+002
Tl-208	3.8000e-003	1.4060e+008	1.0960e-003	4.0551e+001
U-234	1.5000e-003	5.5500e+007	4.3262e-004	1.6007e+001
U-235	2.0000e-004	7.4000e+006	5.7683e-005	2.1343e+000
U-238	1.1000e-003	4.0700e+007	3.1726e-004	1.1738e+001

Buildup

The material reference is : Source

Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

Results - Dose Point # 1 - (158.48, 77.47, 86.36) cm

Energy MeV	Activity photons/sec	Fluence Rate	Fluence Rate	Exposure Rate	Exposure Rate
		MeV/cm ² /sec No Buildup	MeV/cm ² /sec With Buildup	mR/hr No Buildup	mR/hr With Buildup
0.015	1.772e+05	4.499e-100	2.922e-28	3.859e-101	2.506e-29
0.02	9.398e+05	1.652e-45	2.439e-27	5.722e-47	8.448e-29
0.03	1.012e+06	2.874e-17	5.625e-17	2.848e-19	5.575e-19
0.04	2.518e+06	9.786e-10	2.996e-09	4.328e-12	1.325e-11
0.05	8.623e+08	1.558e-04	7.311e-04	4.150e-07	1.947e-06
0.06	1.890e+07	6.247e-05	4.177e-04	1.241e-07	8.298e-07
0.08	7.020e+09	3.272e-01	3.392e+00	5.177e-04	5.367e-03
0.1	1.245e+08	1.968e-02	2.607e-01	3.011e-05	3.988e-04
0.15	5.288e+07	3.648e-02	5.673e-01	6.007e-05	9.343e-04
0.2	3.290e+09	5.205e+00	7.767e+01	9.187e-03	1.371e-01
0.3	6.288e+09	2.937e+01	3.583e+02	5.571e-02	6.797e-01
0.4	1.127e+10	1.112e+02	1.114e+03	2.167e-01	2.171e+00
0.5	5.575e+08	9.766e+00	8.262e+01	1.917e-02	1.622e-01
0.6	1.417e+10	3.953e+02	2.900e+03	7.715e-01	5.660e+00
0.8	2.821e+09	1.632e+02	9.599e+02	3.105e-01	1.826e+00
1.0	9.164e+09	9.292e+02	4.627e+03	1.713e+00	8.529e+00
1.5	5.559e+09	1.535e+03	5.788e+03	2.582e+00	9.737e+00
2.0	7.798e+09	4.247e+03	1.356e+04	6.568e+00	2.098e+01
3.0	1.403e+08	1.875e+02	4.859e+02	2.544e-01	6.592e-01
TOTALS:	6.914e+10	7.613e+03	2.996e+04	1.250e+01	5.054e+01

Results - Dose Point # 2 - (187.48, 77.47, 86.36) cm

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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u>	<u>Exposure Rate</u> <u>mR/hr</u>	<u>Exposure Rate</u> <u>mR/hr</u>
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	1.772e+05	2.931e-100	1.631e-28	2.514e-101	1.399e-29
0.02	9.398e+05	1.226e-45	1.361e-27	4.248e-47	4.715e-29
0.03	1.012e+06	2.960e-17	5.795e-17	2.933e-19	5.743e-19
0.04	2.518e+06	9.851e-10	3.013e-09	4.357e-12	1.333e-11
0.05	8.623e+08	1.547e-04	7.257e-04	4.121e-07	1.933e-06
0.06	1.890e+07	6.194e-05	4.144e-04	1.230e-07	8.230e-07
0.08	7.020e+09	3.244e-01	3.364e+00	5.133e-04	5.323e-03
0.1	1.245e+08	1.950e-02	2.579e-01	2.983e-05	3.946e-04
0.15	5.288e+07	3.605e-02	5.571e-01	5.936e-05	9.175e-04
0.2	3.290e+09	5.131e+00	7.567e+01	9.056e-03	1.336e-01
0.3	6.288e+09	2.879e+01	3.442e+02	5.462e-02	6.529e-01
0.4	1.127e+10	1.084e+02	1.057e+03	2.111e-01	2.059e+00
0.5	5.575e+08	9.457e+00	7.743e+01	1.856e-02	1.520e-01
0.6	1.417e+10	3.803e+02	2.687e+03	7.424e-01	5.246e+00
0.8	2.821e+09	1.550e+02	8.716e+02	2.949e-01	1.658e+00
1.0	9.164e+09	8.710e+02	4.124e+03	1.606e+00	7.602e+00
1.5	5.559e+09	1.394e+03	4.954e+03	2.345e+00	8.335e+00
2.0	7.798e+09	3.754e+03	1.124e+04	5.805e+00	1.739e+01
3.0	1.403e+08	1.587e+02	3.849e+02	2.153e-01	5.222e-01
TOTALS:	6.914e+10	6.865e+03	2.582e+04	1.130e+01	4.375e+01

Results - Dose Point # 3 - (257.48, 77.47, 86.36) cm

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u>	<u>Exposure Rate</u> <u>mR/hr</u>	<u>Exposure Rate</u> <u>mR/hr</u>
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	1.772e+05	2.664e-100	6.244e-29	2.285e-101	5.355e-30
0.02	9.398e+05	1.148e-45	5.211e-28	3.976e-47	1.805e-29
0.03	1.012e+06	2.874e-17	5.628e-17	2.849e-19	5.578e-19
0.04	2.518e+06	9.440e-10	2.884e-09	4.175e-12	1.276e-11
0.05	8.623e+08	1.408e-04	6.558e-04	3.752e-07	1.747e-06
0.06	1.890e+07	5.313e-05	3.487e-04	1.055e-07	6.927e-07
0.08	7.020e+09	2.546e-01	2.523e+00	4.029e-04	3.993e-03
0.1	1.245e+08	1.452e-02	1.793e-01	2.221e-05	2.742e-04
0.15	5.288e+07	2.506e-02	3.491e-01	4.127e-05	5.748e-04
0.2	3.290e+09	3.427e+00	4.474e+01	6.048e-03	7.896e-02
0.3	6.288e+09	1.819e+01	1.899e+02	3.450e-02	3.603e-01
0.4	1.127e+10	6.569e+01	5.587e+02	1.280e-01	1.089e+00
0.5	5.575e+08	5.546e+00	3.965e+01	1.089e-02	7.784e-02
0.6	1.417e+10	2.169e+02	1.343e+03	4.234e-01	2.621e+00
0.8	2.821e+09	8.453e+01	4.197e+02	1.608e-01	7.982e-01
1.0	9.164e+09	4.584e+02	1.932e+03	8.450e-01	3.562e+00
1.5	5.559e+09	6.886e+02	2.216e+03	1.159e+00	3.729e+00
2.0	7.798e+09	1.779e+03	4.885e+03	2.751e+00	7.554e+00
3.0	1.403e+08	7.151e+01	1.619e+02	9.702e-02	2.196e-01
TOTALS:	6.914e+10	3.392e+03	1.179e+04	5.616e+00	2.009e+01

Results - Dose Point # 4 - (357.48, 77.47, 86.36) cm

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u>	<u>Exposure Rate</u> <u>mR/hr</u>	<u>Exposure Rate</u> <u>mR/hr</u>
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	1.772e+05	2.210e-100	2.589e-29	1.896e-101	2.221e-30

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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u>	<u>Fluence Rate</u>	<u>Exposure Rate</u>	<u>Exposure Rate</u>
		<u>MeV/cm²/sec</u>	<u>No Buildup</u>	<u>MeV/cm²/sec</u>	<u>With Buildup</u>
0.02	9.398e+05	1.049e-45	2.161e-28	3.632e-47	7.486e-30
0.03	1.012e+06	2.501e-17	4.893e-17	2.479e-19	4.849e-19
0.04	2.518e+06	6.682e-10	2.027e-09	2.955e-12	8.967e-12
0.05	8.623e+08	8.416e-05	3.852e-04	2.242e-07	1.026e-06
0.06	1.890e+07	2.867e-05	1.832e-04	5.696e-08	3.640e-07
0.08	7.020e+09	1.247e-01	1.188e+00	1.973e-04	1.880e-03
0.1	1.245e+08	6.821e-03	8.027e-02	1.044e-05	1.228e-04
0.15	5.288e+07	1.127e-02	1.483e-01	1.856e-05	2.442e-04
0.2	3.290e+09	1.508e+00	1.858e+01	2.662e-03	3.279e-02
0.3	6.288e+09	7.803e+00	7.707e+01	1.480e-02	1.462e-01
0.4	1.127e+10	2.771e+01	2.240e+02	5.399e-02	4.365e-01
0.5	5.575e+08	2.311e+00	1.578e+01	4.536e-03	3.097e-02
0.6	1.417e+10	8.954e+01	5.314e+02	1.748e-01	1.037e+00
0.8	2.821e+09	3.441e+01	1.648e+02	6.544e-02	3.135e-01
1.0	9.164e+09	1.847e+02	7.556e+02	3.405e-01	1.393e+00
1.5	5.559e+09	2.733e+02	8.613e+02	4.598e-01	1.449e+00
2.0	7.798e+09	7.003e+02	1.894e+03	1.083e+00	2.928e+00
3.0	1.403e+08	2.794e+01	6.270e+01	3.790e-02	8.506e-02
TOTALS:	6.914e+10	1.350e+03	4.606e+03	2.238e+00	7.855e+00

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30 wt% Waste Loading Steel Container

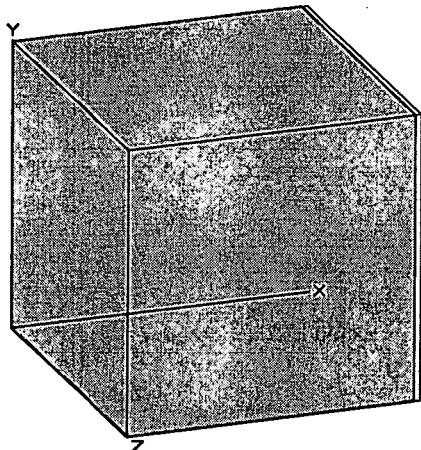
MicroShield v5.01 (5.01-00093)
 Fluor Daniel Fernald

Page : 1
 DOS File: 30BOX118.MS5
 Run Date: March 31, 1999
 Run Time: 2:30:58 PM
 Duration: 00:02:01

File Ref: _____
 Date: _____
 By: _____
 Checked: _____

2552

Case Title: 30 wt%
 Description: 1 1/8" steel box
 Geometry: 13 - Rectangular Volume



Source Dimensions

Length	146.685 cm	4 ft 9.8 in
Width	161.925 cm	5 ft 3.8 in
Height	146.685 cm	4 ft 9.8 in

Dose Points

	X	Y	Z
# 1	150.5425 cm 4 ft 11.3 in	73.3425 cm 2 ft 4.9 in	80.9625 cm 2 ft 7.9 in

Shields

<u>Shield Name</u>	<u>Dimension</u>	<u>Material</u>	<u>Density</u>
Source	3.48e+06 cm ³	Concrete	1.587
Shield 1	2.858 cm	Iron	7.86
Air Gap		Air	0.00122

Source Input

Grouping Method : Standard Indices

Number of Groups : 25

Lower Energy Cutoff : 0.015

Photons < 0.015 : Excluded

Library : Grove

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm³</u>
Ac-227	1.3151e-002	4.8658e+008	3.7746e-003	1.3966e+002
Ac-228	1.9045e-003	7.0466e+007	5.4663e-004	2.0225e+001
Bi-210	3.4627e-001	1.2812e+010	9.9386e-002	3.6773e+003
Bi-211	1.3151e-002	4.8658e+008	3.7746e-003	1.3966e+002
Bi-212	3.9083e-003	1.4461e+008	1.1218e-003	4.1505e+001
Bi-214	8.1768e-001	3.0254e+010	2.3469e-001	8.6836e+003
Pa-231				
Pa-234				
Pa-234m	1.1914e-003	4.4083e+007	3.4197e-004	1.2653e+001
Pb-210	3.4627e-001	1.2812e+010	9.9386e-002	3.6773e+003
Pb-211	1.3151e-002	4.8658e+008	3.7746e-003	1.3966e+002
Pb-212	3.9083e-003	1.4461e+008	1.1218e-003	4.1505e+001
Pb-214	8.1768e-001	3.0254e+010	2.3469e-001	8.6836e+003
Po-210	4.8169e-001	1.7823e+010	1.3826e-001	5.1155e+003
Po-212	3.9083e-003	1.4461e+008	1.1218e-003	4.1505e+001
Po-214	8.1768e-001	3.0254e+010	2.3469e-001	8.6836e+003
Po-215	1.3151e-002	4.8658e+008	3.7746e-003	1.3966e+002
Po-216	3.9083e-003	1.4461e+008	1.1218e-003	4.1505e+001
Po-218	8.1768e-001	3.0254e+010	2.3469e-001	8.6836e+003
Ra-223	1.3151e-002	4.8658e+008	3.7746e-003	1.3966e+002
Ra-224	3.9083e-003	1.4461e+008	1.1218e-003	4.1505e+001
Ra-226	8.1768e-001	3.0254e+010	2.3469e-001	8.6836e+003
Ra-228	1.9045e-003	7.0466e+007	5.4663e-004	2.0225e+001
Rn-219	1.3151e-002	4.8658e+008	3.7746e-003	1.3966e+002
Rn-220	3.9083e-003	1.4461e+008	1.1218e-003	4.1505e+001

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<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm^3</u>
Rn-222	8.1768e-001	3.0254e+010	2.3469e-001	8.6836e+003
Th-227	1.3151e-002	4.8658e+008	3.7746e-003	1.3966e+002
Th-228	3.9083e-003	1.4461e+008	1.1218e-003	4.1505e+001
Th-230	1.1811e-001	4.3699e+009	3.3899e-002	1.2543e+003
Th-231	9.0260e-005	3.3396e+006	2.5907e-005	9.5855e-001
Th-232	1.9045e-003	7.0466e+007	5.4663e-004	2.0225e+001
Th-234	1.1914e-002	4.4083e+008	3.4197e-003	1.2653e+002
Tl-207	1.3151e-002	4.8658e+008	3.7746e-003	1.3966e+002
Tl-208	3.9083e-002	1.4461e+009	1.1218e-002	4.1505e+002
U-234	1.5976e-003	5.9112e+007	4.5855e-004	1.6966e+001
U-235	1.6247e-004	6.0113e+006	4.6632e-005	1.7254e+000
U-238	1.1914e-003	4.4083e+007	3.4197e-004	1.2653e+001

Buildup
 The material reference is : Source

Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

Results

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u>	<u>Fluence Rate</u>	<u>Exposure Rate</u>	<u>Exposure Rate</u>
		<u>MeV/cm²/sec</u>	<u>MeV/cm²/sec</u>	<u>mR/hr</u>	<u>mR/hr</u>
0.015	1.825e+05	0.000e+00	3.669e-28	0.000e+00	3.147e-29
0.02	9.732e+05	1.119e-261	3.078e-27	3.876e-263	1.066e-28
0.03	9.759e+05	1.449e-84	6.826e-27	1.436e-86	6.765e-29
0.04	2.598e+06	1.668e-38	4.818e-26	7.377e-41	2.131e-28
0.05	8.952e+08	2.848e-19	2.789e-18	7.586e-22	7.431e-21
0.06	3.482e+07	3.324e-13	5.461e-12	6.602e-16	1.085e-14
0.08	7.379e+09	9.008e-05	2.014e-03	1.425e-07	3.187e-06
0.1	1.515e+08	3.900e-04	9.222e-03	5.967e-07	1.411e-05
0.15	5.457e+07	1.458e-02	2.795e-01	2.400e-05	4.602e-04
0.2	3.420e+09	4.548e+00	7.121e+01	8.027e-03	1.257e-01
0.3	6.627e+09	3.773e+01	4.364e+02	7.157e-02	8.278e-01
0.4	1.170e+10	1.510e+02	1.404e+03	2.942e-01	2.735e+00
0.5	8.591e+08	1.993e+01	1.558e+02	3.912e-02	3.058e-01
0.6	1.581e+10	5.820e+02	3.949e+03	1.136e+00	7.708e+00
0.8	3.120e+09	2.344e+02	1.283e+03	4.458e-01	2.440e+00
1.0	9.525e+09	1.233e+03	5.752e+03	2.273e+00	1.060e+01
1.5	5.772e+09	1.954e+03	7.013e+03	3.288e+00	1.180e+01
2.0	8.097e+09	5.190e+03	1.599e+04	8.025e+00	2.473e+01
3.0	1.443e+09	2.112e+03	5.403e+03	2.866e+00	7.331e+00
TOTALS:	7.489e+10	1.152e+04	4.146e+04	1.845e+01	6.861e+01

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2552

40 wt% Waste Loading Concrete Container

MicroShield v5.01 (5.01-00093)
 Fluor Daniel Fernald

Page : 1
 DOS File: 40BOX412.MS5
 Run Date: March 31, 1999
 Run Time: 10:54:42 AM
 Duration: 00:07:42

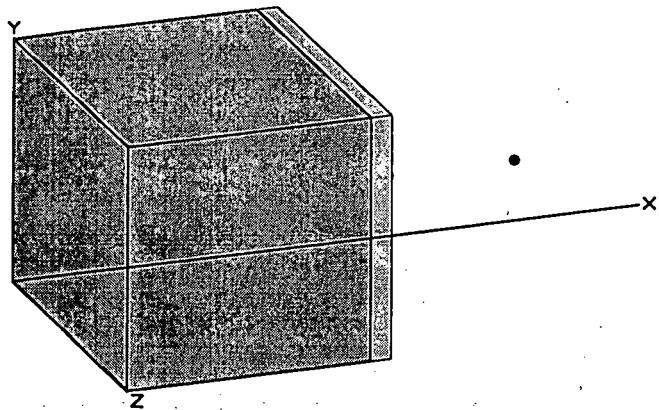
File Ref: _____
 Date: _____
 By: _____
 Checked: _____

2552

Case Title: 40 wt%
 Description: 4 1/2" concrete box
 Geometry: 13 - Rectangular Volume

Source Dimensions

Length	134.62 cm	4 ft 5.0 in
Width	175.26 cm	5 ft 9.0 in
Height	134.62 cm	4 ft 5.0 in



Dose Points

	X	Y	Z
# 1	147.05 cm	67.31 cm	87.63 cm
	4 ft 9.9 in	2 ft 2.5 in	2 ft 10.5 in
# 2	176.05 cm	67.31 cm	87.63 cm
	5 ft 9.3 in	2 ft 2.5 in	2 ft 10.5 in
# 3	246.05 cm	67.31 cm	87.63 cm
	8 ft 0.9 in	2 ft 2.5 in	2 ft 10.5 in
# 4	346.05 cm	67.31 cm	87.63 cm
	11 ft 4.2 in	2 ft 2.5 in	2 ft 10.5 in

Shields

<u>Shield Name</u>	<u>Dimension</u>	<u>Material</u>	<u>Density</u>
Source	3.18e+06 cm ³	Concrete	1.587
Shield 1	11.43 cm	Concrete	2.35
Air Gap		Air	0.00122

Source Input

Grouping Method : Standard Indices

Number of Groups : 25

Lower Energy Cutoff : 0.015

Photons < 0.015 : Excluded

Library : Grove

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm^3</u>
Ac-227	1.6418e-002	6.0748e+008	5.1693e-003	1.9126e+002
Ac-228	2.3793e-003	8.8036e+007	7.4913e-004	2.7718e+001
Bi-210	4.3247e-001	1.6001e+010	1.3616e-001	5.0379e+003
Bi-211	1.6418e-002	6.0748e+008	5.1693e-003	1.9126e+002
Bi-212	4.8772e-003	1.8046e+008	1.5356e-003	5.6816e+001
Bi-214	1.0212e+000	3.7785e+010	3.2152e-001	1.1896e+004
Pa-231				
Pa-234				
Pa-234m	1.4860e-003	5.4980e+007	4.6785e-004	1.7310e+001
Pb-210	4.3247e-001	1.6001e+010	1.3616e-001	5.0379e+003
Pb-211	1.6418e-002	6.0748e+008	5.1693e-003	1.9126e+002
Pb-212	4.8772e-003	1.8046e+008	1.5356e-003	5.6816e+001
Pb-214	1.0212e+000	3.7785e+010	3.2152e-001	1.1896e+004
Po-210	6.0159e-001	2.2259e+010	1.8941e-001	7.0081e+003
Po-212	4.8772e-003	1.8046e+008	1.5356e-003	5.6816e+001
Po-214	1.0212e+000	3.7785e+010	3.2152e-001	1.1896e+004
Po-215	1.6418e-002	6.0748e+008	5.1693e-003	1.9126e+002
Po-216	4.8772e-003	1.8046e+008	1.5356e-003	5.6816e+001
Po-218	1.0212e+000	3.7785e+010	3.2152e-001	1.1896e+004

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<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm^3</u>
Ra-223	1.6418e-002	6.0748e+008	5.1693e-003	1.9126e+002
Ra-224	4.8772e-003	1.8046e+008	1.5356e-003	5.6816e+001
Ra-226	1.0212e+000	3.7785e+010	3.2152e-001	1.1896e+004
Ra-228	2.3793e-003	8.8036e+007	7.4913e-004	2.7718e+001
Rn-219	1.6418e-002	6.0748e+008	5.1693e-003	1.9126e+002
Rn-220	4.8772e-003	1.8046e+008	1.5356e-003	5.6816e+001
Rn-222	1.0212e+000	3.7785e+010	3.2152e-001	1.1896e+004
Th-227	1.6418e-002	6.0748e+008	5.1693e-003	1.9126e+002
Th-228	4.8772e-003	1.8046e+008	1.5356e-003	5.6816e+001
Th-230	1.4751e-001	5.4579e+009	4.6443e-002	1.7184e+003
Th-231	1.1851e-004	4.3849e+006	3.7313e-005	1.3806e+000
Th-232	2.3793e-003	8.8036e+007	7.4913e-004	2.7718e+001
Th-234	1.4860e-003	5.4980e+007	4.6785e-004	1.7310e+001
Tl-207	1.6418e-002	6.0748e+008	5.1693e-003	1.9126e+002
Tl-208	4.8772e-003	1.8046e+008	1.5356e-003	5.6816e+001
U-234	1.9965e-003	7.3869e+007	6.2858e-004	2.3257e+001
U-235	2.0056e-004	7.4206e+006	6.3145e-005	2.3364e+000
U-238	1.4860e-003	5.4980e+007	4.6785e-004	1.7310e+001

Buildup

The material reference is : Source

Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

Results - Dose Point # 1 - (147.05, 67.31, 87.63) cm

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u>	<u>Fluence Rate</u>	<u>Exposure Rate</u>	<u>Exposure Rate</u>
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	2.283e+05	1.538e-109	3.887e-28	1.319e-110	3.334e-29
0.02	1.215e+06	1.335e-49	3.255e-27	4.626e-51	1.128e-28
0.03	1.250e+06	1.434e-18	2.851e-18	1.422e-20	2.826e-20
0.04	3.242e+06	2.455e-10	7.742e-10	1.086e-12	3.424e-12
0.05	1.118e+09	6.899e-05	3.392e-04	1.838e-07	9.035e-07
0.06	2.459e+07	3.590e-05	2.555e-04	7.131e-08	5.075e-07
0.08	9.101e+09	2.335e-01	2.631e+00	3.695e-04	4.163e-03
0.1	1.612e+08	1.536e-02	2.244e-01	2.350e-05	3.433e-04
0.15	6.812e+07	3.112e-02	5.413e-01	5.124e-05	8.913e-04
0.2	4.264e+09	4.679e+00	7.827e+01	8.259e-03	1.381e-01
0.3	8.153e+09	2.793e+01	3.799e+02	5.298e-02	7.206e-01
0.4	1.462e+10	1.097e+02	1.215e+03	2.137e-01	2.368e+00
0.5	7.226e+08	9.896e+00	9.184e+01	1.942e-02	1.803e-01
0.6	1.837e+10	4.093e+02	3.272e+03	7.989e-01	6.387e+00
0.8	3.658e+09	1.745e+02	1.107e+03	3.320e-01	2.105e+00
1.0	1.188e+10	1.018e+03	5.418e+03	1.876e+00	9.987e+00
1.5	7.209e+09	1.748e+03	6.952e+03	2.941e+00	1.170e+01
2.0	1.011e+10	4.957e+03	1.655e+04	7.666e+00	2.560e+01
3.0	1.801e+08	2.229e+02	5.977e+02	3.024e-01	8.109e-01
TOTALS:	8.965e+10	8.682e+03	3.567e+04	1.421e+01	6.000e+01

Results - Dose Point # 2 - (176.05, 67.31, 87.63) cm

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<u>Energy</u>	<u>Activity</u>	<u>Fluence Rate</u>	<u>Fluence Rate</u>	<u>Exposure Rate</u>	<u>Exposure Rate</u>
<u>MeV</u>	<u>photons/sec</u>	<u>MeV/cm²/sec</u>	<u>No Buildup</u>	<u>With Buildup</u>	<u>mR/hr</u>
0.015	2.283e+05	9.736e-110	2.174e-28	8.351e-111	1.864e-29
0.02	1.215e+06	1.021e-49	1.820e-27	3.538e-51	6.305e-29
0.03	1.250e+06	1.484e-18	2.951e-18	1.471e-20	2.924e-20
0.04	3.242e+06	2.462e-10	7.758e-10	1.089e-12	3.431e-12
0.05	1.118e+09	6.840e-05	3.362e-04	1.822e-07	8.956e-07
0.06	2.459e+07	3.558e-05	2.533e-04	7.067e-08	5.032e-07
0.08	9.101e+09	2.315e-01	2.610e+00	3.664e-04	4.130e-03
0.1	1.612e+08	1.522e-02	2.222e-01	2.329e-05	3.399e-04
0.15	6.812e+07	3.077e-02	5.322e-01	5.067e-05	8.764e-04
0.2	4.264e+09	4.616e+00	7.641e+01	8.147e-03	1.349e-01
0.3	8.153e+09	2.741e+01	3.660e+02	5.199e-02	6.942e-01
0.4	1.462e+10	1.070e+02	1.157e+03	2.085e-01	2.254e+00
0.5	7.226e+08	9.597e+00	8.645e+01	1.884e-02	1.697e-01
0.6	1.837e+10	3.945e+02	3.048e+03	7.700e-01	5.949e+00
0.8	3.658e+09	1.661e+02	1.011e+03	3.160e-01	1.922e+00
1.0	1.188e+10	9.563e+02	4.859e+03	1.763e+00	8.956e+00
1.5	7.209e+09	1.593e+03	5.992e+03	2.681e+00	1.008e+01
2.0	1.011e+10	4.399e+03	1.383e+04	6.802e+00	2.138e+01
3.0	1.801e+08	1.895e+02	4.773e+02	2.571e-01	6.475e-01
TOTALS:	8.965e+10	7.848e+03	3.090e+04	1.288e+01	5.219e+01

Results - Dose Point # 3 - (246.05, 67.31, 87.63) cm

<u>Energy</u>	<u>Activity</u>	<u>Fluence Rate</u>	<u>Fluence Rate</u>	<u>Exposure Rate</u>	<u>Exposure Rate</u>
<u>MeV</u>	<u>photons/sec</u>	<u>MeV/cm²/sec</u>	<u>No Buildup</u>	<u>With Buildup</u>	<u>mR/hr</u>
0.015	2.283e+05	8.886e-110	8.295e-29	7.621e-111	7.115e-30
0.02	1.215e+06	9.557e-50	6.947e-28	3.311e-51	2.406e-29
0.03	1.250e+06	1.442e-18	2.866e-18	1.429e-20	2.841e-20
0.04	3.242e+06	2.366e-10	7.449e-10	1.046e-12	3.294e-12
0.05	1.118e+09	6.282e-05	3.069e-04	1.673e-07	8.176e-07
0.06	2.459e+07	3.097e-05	2.170e-04	6.152e-08	4.310e-07
0.08	9.101e+09	1.856e-01	2.011e+00	2.937e-04	3.183e-03
0.1	1.612e+08	1.161e-02	1.593e-01	1.776e-05	2.437e-04
0.15	6.812e+07	2.197e-02	3.455e-01	3.617e-05	5.689e-04
0.2	4.264e+09	3.169e+00	4.685e+01	5.593e-03	8.269e-02
0.3	8.153e+09	1.782e+01	2.094e+02	3.380e-02	3.972e-01
0.4	1.462e+10	6.679e+01	6.338e+02	1.301e-01	1.235e+00
0.5	7.226e+08	5.794e+00	4.584e+01	1.137e-02	8.998e-02
0.6	1.837e+10	2.316e+02	1.575e+03	4.520e-01	3.075e+00
0.8	3.658e+09	9.320e+01	5.024e+02	1.773e-01	9.556e-01
1.0	1.188e+10	5.176e+02	2.347e+03	9.540e-01	4.326e+00
1.5	7.209e+09	8.082e+02	2.755e+03	1.360e+00	4.635e+00
2.0	1.011e+10	2.138e+03	6.162e+03	3.306e+00	9.529e+00
3.0	1.801e+08	8.741e+01	2.054e+02	1.186e-01	2.787e-01
TOTALS:	8.965e+10	3.969e+03	1.448e+04	6.549e+00	2.461e+01

Results - Dose Point # 4 - (346.05, 67.31, 87.63) cm

<u>Energy</u>	<u>Activity</u>	<u>Fluence Rate</u>	<u>Fluence Rate</u>	<u>Exposure Rate</u>	<u>Exposure Rate</u>
<u>MeV</u>	<u>photons/sec</u>	<u>MeV/cm²/sec</u>	<u>No Buildup</u>	<u>With Buildup</u>	<u>mR/hr</u>
0.015	2.283e+05	7.373e-110	3.420e-29	6.324e-111	2.934e-30

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Energy MeV	Activity photons/sec	Fluence Rate	Fluence Rate	Exposure Rate	Exposure Rate
		MeV/cm ² /sec No Buildup	MeV/cm ² /sec With Buildup	mR/hr No Buildup	mR/hr With Buildup
0.02	1.215e+06	8.733e-50	2.864e-28	3.025e-51	9.921e-30
0.03	1.250e+06	1.271e-18	2.525e-18	1.259e-20	2.502e-20
0.04	3.242e+06	1.727e-10	5.404e-10	7.636e-13	2.390e-12
0.05	1.118e+09	3.893e-05	1.873e-04	1.037e-07	4.988e-07
0.06	2.459e+07	1.734e-05	1.184e-04	3.444e-08	2.352e-07
0.08	9.101e+09	9.410e-02	9.809e-01	1.489e-04	1.552e-03
0.1	1.612e+08	5.634e-03	7.367e-02	8.619e-06	1.127e-04
0.15	6.812e+07	1.018e-02	1.511e-01	1.676e-05	2.488e-04
0.2	4.264e+09	1.434e+00	1.998e+01	2.532e-03	3.526e-02
0.3	8.153e+09	7.843e+00	8.701e+01	1.488e-02	1.651e-01
0.4	1.462e+10	2.887e+01	2.597e+02	5.624e-02	5.061e-01
0.5	7.226e+08	2.470e+00	1.861e+01	4.849e-03	3.653e-02
0.6	1.837e+10	9.772e+01	6.355e+02	1.907e-01	1.240e+00
0.8	3.658e+09	3.871e+01	2.008e+02	7.364e-02	3.820e-01
1.0	1.188e+10	2.126e+02	9.329e+02	3.919e-01	1.720e+00
1.5	7.209e+09	3.263e+02	1.086e+03	5.490e-01	1.828e+00
2.0	1.011e+10	8.549e+02	2.421e+03	1.322e+00	3.744e+00
3.0	1.801e+08	3.463e+01	8.052e+01	4.698e-02	1.092e-01
TOTALS:	8.965e+10	1.606e+03	5.744e+03	2.653e+00	9.768e+00

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40 wt% Waste Loading Steel Container

MicroShield v5.01 (5.01-00093)
Fluor Daniel Fernald

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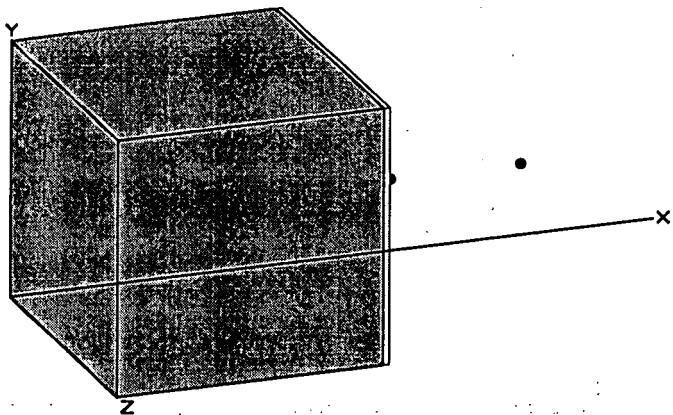
File Ref: _____
Date: _____
By: _____
Checked: _____

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Case Title: 40 wt%

Description: 1 1/4" Steel box

Geometry: 13 - Rectangular Volume



Source Dimensions

Length	143.51 cm	4 ft 8.5 in
Width	161.29 cm	5 ft 3.5 in
Height	140.97 cm	4 ft 7.5 in

Dose Points

	X	Y	Z
# 1	147.685 cm	70.485 cm	80.645 cm
	4 ft 10.1 in	2 ft 3.8 in	2 ft 7.7 in
# 2	176.685 cm	70.485 cm	80.645 cm
	5 ft 9.6 in	2 ft 3.8 in	2 ft 7.7 in
# 3	246.685 cm	70.485 cm	80.645 cm
	8 ft 1.1 in	2 ft 3.8 in	2 ft 7.7 in
# 4	346.685 cm	70.485 cm	80.645 cm
	11 ft 4.5 in	2 ft 3.8 in	2 ft 7.7 in

Shields

<u>Shield Name</u>	<u>Dimension</u>	<u>Material</u>	<u>Density</u>
Source	3.26e+06 cm ³	Concrete	1.587
Shield 1	3.175 cm	Iron	7.86
Air Gap		Air	0.00122

Source Input

Grouping Method : Standard Indices

Number of Groups : 25

Lower Energy Cutoff : 0.015

Photons < 0.015 : Excluded

Library : Grove

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm^3</u>
Ac-227	1.6867e-002	6.2409e+008	5.1693e-003	1.9126e+002
Ac-228	2.4444e-003	9.0443e+007	7.4913e-004	2.7718e+001
Bi-210	4.4429e-001	1.6439e+010	1.3616e-001	5.0379e+003
Bi-211	1.6867e-002	6.2409e+008	5.1693e-003	1.9126e+002
Bi-212	5.0105e-003	1.8539e+008	1.5356e-003	5.6816e+001
Bi-214	1.0491e+000	3.8818e+010	3.2152e-001	1.1896e+004
Pa-231				
Pa-234				
Pa-234m	1.5266e-003	5.6483e+007	4.6785e-004	1.7310e+001
Pb-210	4.4429e-001	1.6439e+010	1.3616e-001	5.0379e+003
Pb-211	1.6867e-002	6.2409e+008	5.1693e-003	1.9126e+002
Pb-212	5.0105e-003	1.8539e+008	1.5356e-003	5.6816e+001
Pb-214	1.0491e+000	3.8818e+010	3.2152e-001	1.1896e+004
Po-210	6.1804e-001	2.2867e+010	1.8941e-001	7.0081e+003
Po-212	5.0105e-003	1.8539e+008	1.5356e-003	5.6816e+001
Po-214	1.0491e+000	3.8818e+010	3.2152e-001	1.1896e+004
Po-215	1.6867e-002	6.2409e+008	5.1693e-003	1.9126e+002
Po-216	5.0105e-003	1.8539e+008	1.5356e-003	5.6816e+001
Po-218	1.0491e+000	3.8818e+010	3.2152e-001	1.1896e+004

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<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>$\mu\text{Ci}/\text{cm}^3$</u>	<u>Bq/cm^3</u>
Ra-223	1.6867e-002	6.2409e+008	5.1693e-003	1.9126e+002
Ra-224	5.0105e-003	1.8539e+008	1.5356e-003	5.6816e+001
Ra-226	1.0491e+000	3.8818e+010	3.2152e-001	1.1896e+004
Ra-228	2.4444e-003	9.0443e+007	7.4913e-004	2.7718e+001
Rn-219	1.6867e-002	6.2409e+008	5.1693e-003	1.9126e+002
Rn-220	5.0105e-003	1.8539e+008	1.5356e-003	5.6816e+001
Rn-222	1.0491e+000	3.8818e+010	3.2152e-001	1.1896e+004
Th-227	1.6867e-002	6.2409e+008	5.1693e-003	1.9126e+002
Th-228	5.0105e-003	1.8539e+008	1.5356e-003	5.6816e+001
Th-230	1.5154e-001	5.6071e+009	4.6443e-002	1.7184e+003
Th-231	1.2175e-004	4.5048e+006	3.7313e-005	1.3806e+000
Th-232	2.4444e-003	9.0443e+007	7.4913e-004	2.7718e+001
Th-234	1.5266e-003	5.6483e+007	4.6785e-004	1.7310e+001
Tl-207	1.6867e-002	6.2409e+008	5.1693e-003	1.9126e+002
Tl-208	5.0105e-003	1.8539e+008	1.5356e-003	5.6816e+001
U-234	2.0510e-003	7.5889e+007	6.2858e-004	2.3257e+001
U-235	2.0604e-004	7.6235e+006	6.3145e-005	2.3364e+000
U-238	1.5266e-003	5.6483e+007	4.6785e-004	1.7310e+001

Buildup

The material reference is : Source

Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

Results - Dose Point # 1 - (147.685, 70.485, 80.645) cm

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u>	<u>Fluence Rate</u>	<u>Exposure Rate</u>	<u>Exposure Rate</u>
		<u>MeV/cm²/sec</u> <u>No Buildup</u>	<u>MeV/cm²/sec</u> <u>With Buildup</u>	<u>mR/hr</u> <u>No Buildup</u>	<u>mR/hr</u> <u>With Buildup</u>
0.015	2.345e+05	0.000e+00	4.860e-28	0.000e+00	4.169e-29
0.02	1.248e+06	1.242e-288	4.070e-27	4.301e-290	1.410e-28
0.03	1.284e+06	5.578e-93	9.259e-27	5.528e-95	9.177e-29
0.04	3.331e+06	3.705e-42	6.369e-26	1.638e-44	2.817e-28
0.05	1.149e+09	3.490e-21	3.518e-20	9.298e-24	9.372e-23
0.06	2.527e+07	1.377e-14	2.503e-13	2.734e-17	4.972e-16
0.08	9.350e+09	2.765e-05	6.869e-04	4.376e-08	1.087e-06
0.1	1.656e+08	1.759e-04	4.684e-03	2.691e-07	7.166e-06
0.15	6.998e+07	1.169e-02	2.506e-01	1.926e-05	4.126e-04
0.2	4.380e+09	4.098e+00	7.119e+01	7.232e-03	1.256e-01
0.3	8.376e+09	3.652e+01	4.636e+02	6.927e-02	8.793e-01
0.4	1.502e+10	1.542e+02	1.559e+03	3.005e-01	3.038e+00
0.5	7.423e+08	1.405e+01	1.186e+02	2.758e-02	2.328e-01
0.6	1.887e+10	5.774e+02	4.208e+03	1.127e+00	8.213e+00
0.8	3.758e+09	2.409e+02	1.403e+03	4.583e-01	2.669e+00
1.0	1.221e+10	1.375e+03	6.779e+03	2.534e+00	1.250e+01
1.5	7.406e+09	2.250e+03	8.436e+03	3.785e+00	1.419e+01
2.0	1.039e+10	6.082e+03	1.946e+04	9.405e+00	3.009e+01
3.0	1.850e+08	2.520e+02	6.641e+02	3.419e-01	9.010e-01
TOTALS:	9.210e+10	1.099e+04	4.316e+04	1.806e+01	7.284e+01

Results - Dose Point # 2 - (176.685, 70.485, 80.645) cm

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<u>Energy</u>	<u>Activity</u>	<u>Fluence Rate</u>	<u>Fluence Rate</u>	<u>Exposure Rate</u>	<u>Exposure Rate</u>
MeV	photons/sec	MeV/cm ² /sec	MeV/cm ² /sec	mR/hr	mR/hr
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	2.345e+05	0.000e+00	2.525e-28	0.000e+00	2.166e-29
0.02	1.248e+06	4.828e-283	2.114e-27	1.672e-284	7.324e-29
0.03	1.284e+06	4.946e-92	4.810e-27	4.902e-94	4.767e-29
0.04	3.331e+06	4.068e-42	3.309e-26	1.799e-44	1.463e-28
0.05	1.149e+09	2.412e-21	2.426e-20	6.426e-24	6.446e-23
0.06	2.527e+07	9.584e-15	1.762e-13	1.904e-17	3.499e-16
0.08	9.350e+09	2.444e-05	6.236e-04	3.867e-08	9.869e-07
0.1	1.656e+08	1.744e-04	4.728e-03	2.668e-07	7.233e-06
0.15	6.998e+07	1.190e-02	2.531e-01	1.959e-05	4.168e-04
0.2	4.380e+09	4.137e+00	7.107e+01	7.301e-03	1.254e-01
0.3	8.376e+09	3.653e+01	4.570e+02	6.930e-02	8.668e-01
0.4	1.502e+10	1.533e+02	1.522e+03	2.988e-01	2.965e+00
0.5	7.423e+08	1.390e+01	1.147e+02	2.729e-02	2.252e-01
0.6	1.887e+10	5.685e+02	4.037e+03	1.110e+00	7.880e+00
0.8	3.758e+09	2.350e+02	1.326e+03	4.470e-01	2.522e+00
1.0	1.221e+10	1.328e+03	6.312e+03	2.448e+00	1.163e+01
1.5	7.406e+09	2.124e+03	7.599e+03	3.573e+00	1.279e+01
2.0	1.039e+10	5.624e+03	1.707e+04	8.697e+00	2.640e+01
3.0	1.850e+08	2.257e+02	5.617e+02	3.062e-01	7.621e-01
TOTALS:	9.210e+10	1.031e+04	3.907e+04	1.698e+01	6.616e+01

Results - Dose Point # 3 - (246.685, 70.485, 80.645) cm

<u>Energy</u>	<u>Activity</u>	<u>Fluence Rate</u>	<u>Fluence Rate</u>	<u>Exposure Rate</u>	<u>Exposure Rate</u>
MeV	photons/sec	MeV/cm ² /sec	MeV/cm ² /sec	mR/hr	mR/hr
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	2.345e+05	0.000e+00	9.120e-29	0.000e+00	7.823e-30
0.02	1.248e+06	3.594e-283	7.638e-28	1.245e-284	2.646e-29
0.03	1.284e+06	5.108e-92	1.738e-27	5.062e-94	1.722e-29
0.04	3.331e+06	3.967e-42	1.195e-26	1.754e-44	5.286e-29
0.05	1.149e+09	2.368e-21	2.380e-20	6.308e-24	6.340e-23
0.06	2.527e+07	9.432e-15	1.734e-13	1.873e-17	3.444e-16
0.08	9.350e+09	2.365e-05	6.011e-04	3.742e-08	9.512e-07
0.1	1.656e+08	1.604e-04	4.256e-03	2.454e-07	6.511e-06
0.15	6.998e+07	9.474e-03	1.866e-01	1.560e-05	3.073e-04
0.2	4.380e+09	3.015e+00	4.633e+01	5.321e-03	8.177e-02
0.3	8.376e+09	2.427e+01	2.645e+02	4.605e-02	5.017e-01
0.4	1.502e+10	9.656e+01	8.294e+02	1.881e-01	1.616e+00
0.5	7.423e+08	8.415e+00	6.006e+01	1.652e-02	1.179e-01
0.6	1.887e+10	3.334e+02	2.051e+03	6.508e-01	4.004e+00
0.8	3.758e+09	1.310e+02	6.443e+02	2.492e-01	1.226e+00
1.0	1.221e+10	7.117e+02	2.970e+03	1.312e+00	5.475e+00
1.5	7.406e+09	1.061e+03	3.388e+03	1.784e+00	5.701e+00
2.0	1.039e+10	2.688e+03	7.374e+03	4.157e+00	1.140e+01
3.0	1.850e+08	1.026e+02	2.351e+02	1.392e-01	3.189e-01
TOTALS:	9.210e+10	5.160e+03	1.786e+04	8.548e+00	3.044e+01

Results - Dose Point # 4 - (346.685, 70.485, 80.645) cm

<u>Energy</u>	<u>Activity</u>	<u>Fluence Rate</u>	<u>Fluence Rate</u>	<u>Exposure Rate</u>	<u>Exposure Rate</u>
MeV	photons/sec	MeV/cm ² /sec	MeV/cm ² /sec	mR/hr	mR/hr
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	2.345e+05	0.000e+00	3.652e-29	0.000e+00	4.132e-30

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Energy MeV	Activity photons/sec	Fluence Rate	Fluence Rate	Exposure Rate	Exposure Rate
		MeV/cm ² /sec No Buildup	MeV/cm ² /sec With Buildup	mR/hr No Buildup	mR/hr With Buildup
0.02	1.248e+06	3.269e-283	3.058e-28	1.132e-284	1.059e-29
0.03	1.284e+06	4.909e-92	6.957e-28	4.865e-94	6.895e-30
0.04	3.331e+06	3.849e-42	4.786e-27	1.702e-44	2.117e-29
0.05	1.149e+09	2.251e-21	2.261e-20	5.996e-24	6.024e-23
0.06	2.527e+07	8.338e-15	1.521e-13	1.656e-17	3.021e-16
0.08	9.350e+09	1.673e-05	4.140e-04	2.647e-08	6.551e-07
0.1	1.656e+08	9.463e-05	2.391e-03	1.448e-07	3.658e-06
0.15	6.998e+07	4.542e-03	8.373e-02	7.480e-06	1.379e-04
0.2	4.380e+09	1.346e+00	1.934e+01	2.376e-03	3.413e-02
0.3	8.376e+09	1.027e+01	1.051e+02	1.948e-02	1.995e-01
0.4	1.502e+10	3.986e+01	3.236e+02	7.767e-02	6.306e-01
0.5	7.423e+08	3.420e+00	2.320e+01	6.713e-03	4.553e-02
0.6	1.887e+10	1.340e+02	7.869e+02	2.615e-01	1.536e+00
0.8	3.758e+09	5.181e+01	2.450e+02	9.855e-02	4.660e-01
1.0	1.221e+10	2.783e+02	1.124e+03	5.131e-01	2.071e+00
1.5	7.406e+09	4.079e+02	1.273e+03	6.864e-01	2.143e+00
2.0	1.039e+10	1.026e+03	2.765e+03	1.586e+00	4.276e+00
3.0	1.850e+08	3.893e+01	8.819e+01	5.281e-02	1.196e-01
TOTALS:	9.210e+10	1.992e+03	6.753e+03	3.305e+00	1.152e+01

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